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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : H04H 5/00 | A1

(11) International Publication Number: WO 95/33319

(43) International Publication Date: 7 December 1995 (07.12.95)

(21) International Application Number: PCT/US94/06127

(22) International Filing Date: 1 June 1994 (01.06.94)

(71) Applicant: RECOTON CORPORATION [US/US]; 46-23 Crane Street, Long Island City, NY 11101 (US).

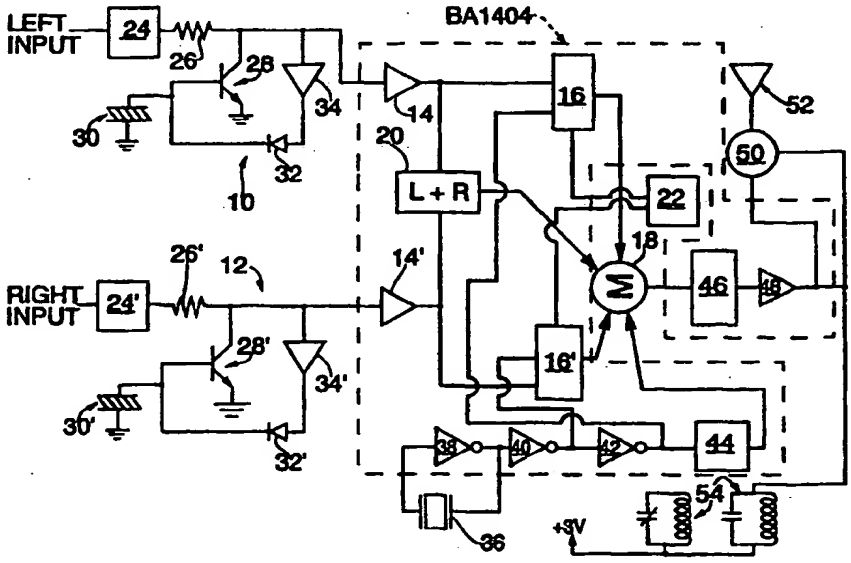
(72) Inventor: McGreevy, William, T.; 43 Thompson Avenue, Babylon, NY 11701 (US).

(74) Agent: BERGER, Peter, L.; Levisohn, Lerner & Berger, Suite 2400, 757 Third Avenue, New York, NY 10017 (US).

(81) Designated States: CA, GB, JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: UNINTENTIONAL POWER RADIATION FM TRANSMISSION SYSTEM



(57) Abstract

This invention discloses a wireless compact disc stereo playback system for use in automobiles. An FM transmitter (BA 1404) is employed which is connected at the output of a portable CD player, the FM transmitter (BA 1404) thereby producing a stereo FM signal which is transmitted (via 52) to be received by the automobile antenna. The automobile's FM system is tuned to play the output of the CD player through the FM radio system of the automobile. The FM transmitter (BA 1404) operates below the unintentional power radiator range of 250 microvolts per meter at three meters as set by the FCC. Another embodiment of this invention employs a transmission system in which the audio signals are spread over a spectrum for transmission below the unintentional power range and are recombined at the receiver.

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UNINTENTIONAL POWER RADIATION FM TRANSMISSION SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to a novel system for FM transmission which materially enlarges the scope of small distance communications without materially increasing unwanted interference.

There exists a plethora of private FCC regulated FM transmission systems. Such regulation is necessary for many reasons, not the least of which is to prevent interference.

The FCC has identified a series of FM system parameters for regulation. FM signals below the FCC regulated range are identified as unintentional power radiators. The theory is that the FCC does not need to regulate FM below the power of such unintentional radiators because there is very little concern about FM interference.

The present invention is directed to intentionally providing FM systems that operate below the unintentional power radiation level in order to provide wireless FM transmission for relatively limited distances, but which may find wide applicability to the home, automobile or office environment

where the distance between the transmitter and receiver is not very large. Such consumer products as telephones, remote control devices, alarms and other products may utilize the transmission systems of this invention.

An illustrative example of the use of this invention applies to a wireless CD/automobile radio adapter which is the subject of my prior U.S. application Serial No. 08/032,444.

SUMMARY OF THE INVENTION

A wireless FM transmitter is provided connected at the output of a portable CD player, the wireless FM transmitter being tunable to an FM radio station so that when the radio is tuned to the desired station, it will play the output of the CD through its antenna which picks up the radio frequency of the FM transmitter produced by the CD player. A standard Rohm integrated circuit is employed as the FM transmitter for stereo transmission, and this invention further comprises a compression circuit at the input of the FM transmitter as well as a DC balance circuit to balance the stereo output of the FM transmitter.

The bandwidth and power of the transmitter allows the device to transmit below appropriate FCC regulations for unintentional radiators, and the level of the transmitted signals is below 25 microvolts per meter at three meters with a bandwidth of 200 kilohertz. This will allow the antenna of the automobile radio to pick up the output of the transmitter to play the output

signal through the antenna input into the FM radio of the automobile. In this manner, the wireless CD adapter can be used anywhere in the automobile. The FM transmitter transmits stereo sound through the antenna into the FM radio which then plays through the FM radio at a non-used FM signal in the local area.

Most FM radios can be tuned to operate outside the FM band of 88-108 MHz by up to one MHz. As a feature of this invention, the FM transmitter is permanently set to be outside the normal FM band which enables this transmission system to operate at its own permanent FM frequency without needing to hunt for a non-used FM frequency.

While the above illustrative system can work up to a distance of approximately ten feet, another aspect of this invention is to provide a spread spectrum of unintentional radiators which are collected or summed at the receiver so that the effective distance for clear FM transmission can be materially enhanced while the transmitter operates below the unintentional power radiator level.

This invention may be used worldwide, and the only variation will be that the unintentional radiator power range may vary from country to country or region to region. . It is anticipated that no FCC or other regulatory permission will be required to permit such unintentional radiator transmission systems to operate.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram of the wireless CD adapter stereo system.

Figs. 2A and 2B are block diagrams of a transmitter and receiver implementing another embodiment of this invention in which a plurality of unintentional radiators are transmitted in a spread spectrum to enhance the range of the system.

Fig. 3 is a block diagram of a PN code register used in this invention.

DETAILED DESCRIPTION

Figure 1 illustrates an embodiment of this invention in which a standard Rohm BA 1404 integrated circuit is employed. That circuitry is illustrated within the dotted lines and comprises substantially standard FM transmitter circuitry. In particular, there is a left and a right channel 10 and 12, respectively, with the left channel including a pre-amp buffer 14, the output of which is applied to a balance modulator 16, the output of the balance modulator being supplied to a multiplexer circuit 18. The right channel 12 has the above-identified pre-amp buffer 14' and balance modulator 16' connected to the output of the pre-amp buffer 14' the output of the balance modulator 16' being supplied as an input to multiplexer 18. A summation circuit 20 is connected between the outputs of the pre-amp buffers 14 and 14', and the output summation circuit 20 is supplied to a composite mixer 18. The outputs of the balance modulators 16 and 16' are supplied to

a manually operated DC balance circuit 22 which adjusts the volume between the left and right channels of the FM system.

A compressor circuit generally shown by the numerals 10 and 12 is connected between the output of the CD and the input of the respective channels of the FM circuits. The compressor circuit comprises a pre-emphasis amplifier 24 which essentially operates at seventy-five microseconds and serves as a high frequency amplifier to improve the signal-to-noise characteristics of the circuit. The output of the pre-emphasis amplifier 24 is connected through a resistor 26 to the collector of an NPN transistor 28, the base of which is connected to a Zener diode 30 and to the collector through a diode 32 and series-connected amplifier 34.

The left and right sections of the FM transmitter are each provided with the above-identified compressor circuit which improves the signal-to-noise characteristics of the FM transmitter. The left section is described above, and the same description applies to the right circuit, the elements of which are designated with primed numerals.

A 19 KHz pilot signal, used for signaling receivers to enter stereo mode is provided from a 38 KHz quartz crystal which regulates an oscillator composed of digital inverters 35, 40, the output of amplifier 40 also being supplied as one input to the balance modulator 16', while the output of an amplifier 42 is supplied to balance modulator 16. A divider 44 is provided between the output of amplifier 42 and the composite mixer 18, the output of

the composite mixer 18 being supplied as an input through a voltage controlled oscillator 46, the output of which is supplied through an RF amplifier 48 to an attenuator 50 and an internal antenna 52 of the transmitter. The VCO 46 is tuned in a standard fashion through a plurality of reactive components 54 manually controllable to adjust the transmission frequency of the FM transmitter in order to select a frequency band which is not used in the local area of the FM radio system.

In operation, the portable CD player is operated, and its outputs are supplied as inputs to the left and right sections of the compressor circuits indicated above. The automobile FM radio is turned on, and an FM band is selected, the FM band being one not utilized in the local area. The tuner of the transmitter of this invention is also set at the same frequency so that the antenna transmits at the pre-selected FM frequency, which frequency is detected by the antenna of an automobile to then allow the detected signal to play through the FM radio of the automobile. As an alternative, the preselected FM frequency can be permanently set to be slightly outside the standard FM band of 88-108 MHz, for instance at 87.5 MHz or 108.5 MHz. The normal FM radio receiver in a car can detect such transmitted frequencies, and this eliminates the need to adjust or change the FM transmitter frequency.

The circuitry is designed to insure that the transmitter operates within the restrictions of the FCC in the frequency range of FM radio, and the RF

transmission level does not exceed 250 microvolts per meter at three meters with a bandwidth limited to 200 kilohertz. This RF level enables the transmitter inside a car to easily couple the stereo FM signal from the CD player into the car radio's antenna. The transmitter uses standard multiplex circuitry with the previously identified 19 kilohertz pilot signal so as to be compatible with any FM receiver, and at transmission frequencies selectable which can be set at a frequency that is not being used in the area of use.

It is anticipated that the transmitter is controlled to operate at a power range which enables the transmitter to be effective at distances of up to ten feet from the automobile's antenna. This allows the CD adapter to be used anywhere within an automobile or a van.

As stated above, a standard Rohm BA 1404 circuit is employed, and the FM transmitter can be an integrated circuit. This provides for low cost, compact size and a low power drain. The frequency response of the circuit may be excellent, stereo separation is easy to achieve, the signal-to-noise ratio is at a desirable level, and distortion is minimized. Desirable modulation levels can also be achieved with this invention.

The output band of the FM circuit is designed to maximize output power levels permitted under FCC regulations to provide a system which is conveniently designed to operate at a distance which would be most effective to couple the transmitter's output to the automobile's antenna input without detracting from overall sound performance. Choosing a distance of ten feet

as that desired enables the desired output level to be achieved with the limited band within 200 kilohertz.

This invention has been described with respect to a CD player. In view of the rapidly changing sound production systems including DAT and the like, the wireless adapter is not limited for use with a CD player. In particular, it may be used with a DAT tape player, depending upon its configuration or with any other portable audio signal production device.

Figures 2A and 2B are block diagrams of an FM transmitter and receiver system spreading the power of the transmitted signal over a spectrum for transmission, receiving the same and combining the received signals so as to enhance the range of the transmission system.

The audio input 60 to transmitter 61 is supplied to a voltage controlled oscillator 62, the output of which passes through an amplifier 64 to an FM mixer 66 which is of the double balanced type. The voltage supply to VCO 62 is adjustable by potentiometer 63 in order to provide means to ensure that transmission of transmitter 61 is below the unintentional power level. A clock oscillator 68 is supplied through a PN code register 70 to supply the beat input of mixer 66 which is supplied through an amplifier 72 to an antenna 74. The PN code register contains information about the coding of the beat signal supplied to double mixer which is detected at the receiver. By using the double balanced mixer 66, the audio input is spread over a plurality of transmission frequencies with the transmitted power at each transmission

frequency being blow the unintentional power range. While reference is made to audio input 60, any input can be utilized including video. Additionally, the spread spectrum system employed in the transmitter also helps to maintain transmitted signals below the unintentional power range by spreading the audio input over a plurality of carrier bands.

The PN code register 70 produces a pseudo random rapid binary sequence signal which accomplishes the spreading of the spectrum in a manner which is recapturable at the receiver.

Fig. 2B is a block diagram of a receiver 75 used to collect the plurality of spread transmission frequencies and combine them to provide an overall power level which enhances the range of the FM transmission system.

Antenna 76 receives the unintentional transmitted signals and supplies them through an RF amplifier 78 which then supplies the signal through a wide band pass filter 80. The wide band pass filter accepts the spread spectrum and is supplied to a double balanced mixer 82. The output of mixer 82 is supplied through a narrow band pass filter 84 to an FM Intermediate Frequency Amplifier (FMIF) 86 having a detector and a received signal strength indicator (RSSI) output 88 which is supplied to a clock generator and logic block 90. Narrow band filter 88 is provided to pass the frequencies generated at the VCO 62 of the transmitter 61 while suppressing the carrier. Chip CA 3089 or Philips Chip NE 605 can be used for FMIF 86. The RSSI provides the control clock to operate the clock generator logic block 90, the

output of which is supplied to PN code register 94. The PN code register 94 has the identical pseudo random distribution characteristics of PN code register 70 in the transmitter. The output of PN code register 94 is supplied to mixer 83.

The feed back path provided by the RSSI loop in receiver 75 operates to synchronize the operation of PN code register 94 with PN code register 70 of transmitter 61. In effect the feedback path operates as a sliding correlator to align the pseudo random clocks in the transmitter 61 and receiver 75.

The output of FMIF 86 is the recombined audio 60 which was supplied to VCO 62 at the transmitter 61. The recombined audio enhances the range of the FM system by employing the FM spread spectrum system illustrated in Figs. 2A and 2B. The transmitted power level at each of the carrier bands of the spread spectrum is below the unintentional power level.

Fig. 3 is a block diagram of an illustrative PN code register, whether it be at the transmitter 61 or receiver 75. The PN code register comprises a shift register 96 comprised of a series of eight stages having a serial input and parallel output with the output of the second 98 and fifth 100 stages combined as inputs to an exclusive OR circuit 102, the output of which is supplied to the input of the first stage 104. A clock 106 supplies each stage of the shift register, and the coded output of the register is supplied at the output of the eighth stage 108.

A double-balanced mixer which may be used in either the transmitter 61 or receiver 75 is shown on page 4-85 of Signetics, Linear Data Manual Vol. 1, Communications published in 1989 which shows the input portion of an NE 612 Chip.

This invention has been described with respect to a preferred embodiment, and the scope of this invention is identified in the appended claims. It is anticipated that one of ordinary skill in the art will employ the principles of this invention and make modifications to the specific embodiments illustrated, and such modifications will not depart from the scope of the invention as protected by the claims appended hereto.

WHAT IS CLAIMED:

1. An FM transmission system comprising an FM transmitter and an FM receiver,

said FM transmitter transmitting RF signals, said FM transmitter comprising means to ensure that said transmitted RF signals are at a power level below the FCC unintentional power radiator range of 250 microvolts per meter at three meters, and

an FM receiver comprising means to receive said RF signals operating below said unintentional power radiator level.

2. An FM transmission system according to claim 1, further comprising spread spectrum means to spread the audio input at the transmitter over a plurality of carrier frequencies, said receiver comprising means to combine said plurality of carrier frequencies to recombine said audio input.

3. An FM transmission system according to claim 2, wherein said means to ensure that said transmitted RF signals are below said unintentional power radiator level comprises a voltage controlled oscillator to receive said audio input and means to control the output level of said voltage controller oscillator.

4. An FM transmission system according to claim 1, wherein said means to ensure that said transmitted RF signals are below said unintentional power radiator level comprises a voltage controlled oscillator to receive said

audio input and means to control the output level of said voltage controller oscillator.

5. An FM transmission system according to claim 2, wherein said spread spectrum means comprises a mixer having two inputs, one of said inputs receiving said audio input and the other input receiving a pseudo random clock signal to spread the audio input over said plurality of carrier frequencies.

6. An FM transmission system according to claim 3, wherein said spread spectrum means comprises a mixer having two inputs, one of said inputs receiving said audio input and the other input receiving a pseudo random clock signal to spread the audio input over said plurality of carrier frequencies.

7. An FM transmission system according to claim 5, wherein said receiver comprises means to synchronize the received signal with the pseudo random clock signal of said transmitter, and detector means to combine said spread spectrum to form an audio signal.

8. An FM transmission system according to claim 6, wherein said receiver comprises means to synchronize the received signal with the pseudo random clock signal of said transmitter, and detector means to combine said spread spectrum to form an audio signal.

9. In combination, a wireless compact disc player/automobile radio adapter, an FM radio in an automobile and an antenna of said

automobile connected to said FM radio, said adapter operating to couple radio frequency signals to said FM radio in said automobile through the antenna of the automobile, said adapter comprising

a wireless radio frequency transmitter connected to receive as input signals the output of said compact disc player, said transmitter controlled to operate slightly outside the normal FM frequency range of 88-108 MHz,

said transmitter power operates below appropriate FCC regulations in the power range of unintentional power radiators, said transmitter to be used within said automobile and having sufficient power to generate a radio frequency signal which will be detected by the antenna of said automobile, said transmitter transmitting radio frequency signals which are detected by the antenna of the radio of the automobile,

said adapter including said transmitter being portable and movable within said automobile without interruption of transmission of said radio frequency signals,

said adapter operable to operate within said automobile when it is moving by coupling said radio frequency signal emanating from the transmitter to the antenna of the automobile,

said transmitter transmitting at said transmission frequency such that the FM radio of said automobile is tunable to said transmission frequency to enable the compact disc player to play through the antenna input to the FM radio of the automobile.

10. The combination of claim 9, wherein said transmitter is controlled to operate outside the normal FM range of 88-108 MHz by no more than one MHz.

11. The combination of claim 9, wherein said transmitter is controlled to operate outside the normal FM range of 88-108 MHz by no more than 0.5 MHz.

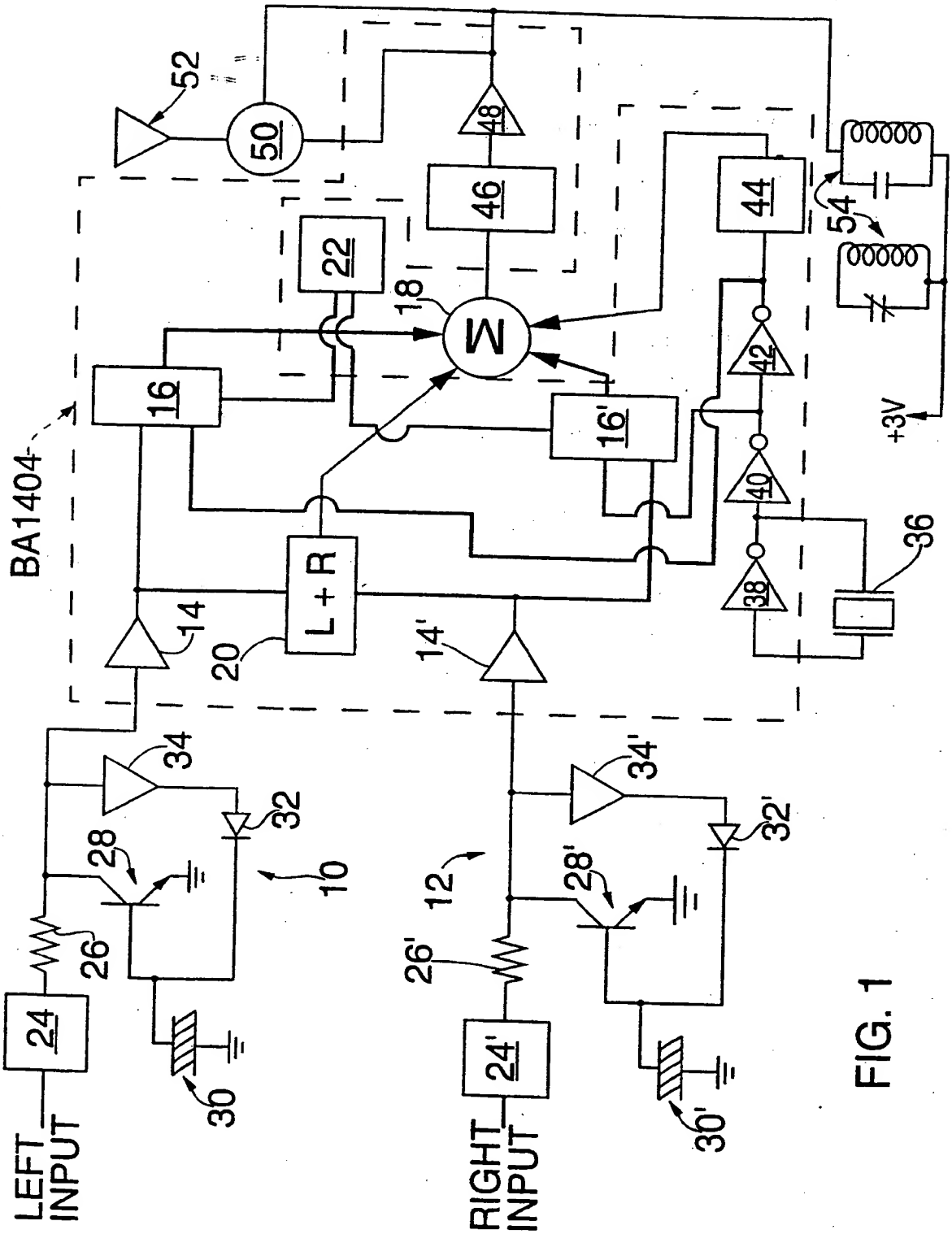
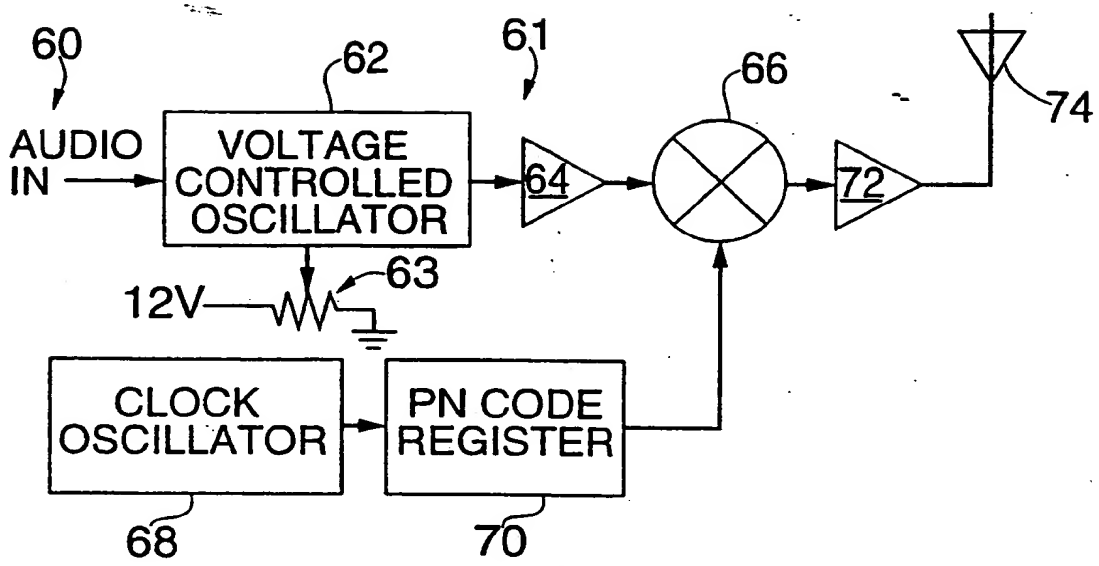


FIG. 1


60
62
61
66
74
AUDIO IN
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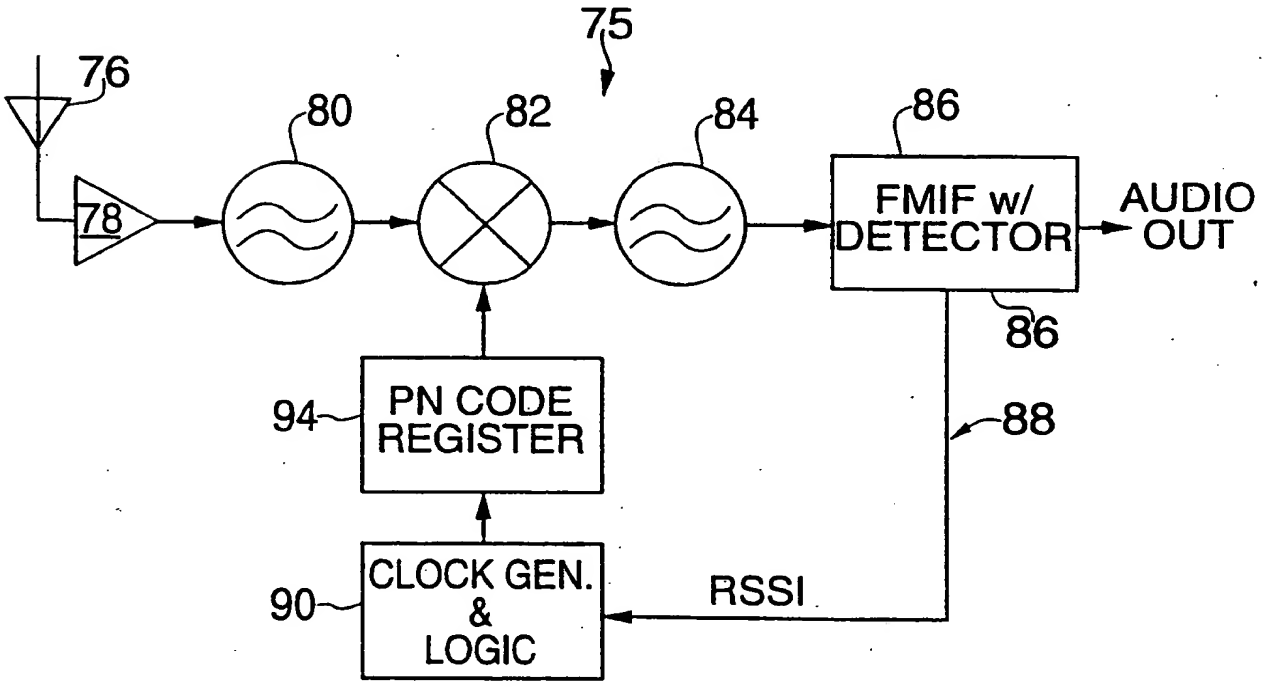
64
72
12V
63
CLOCK OSCILLATOR
PN CODE REGISTER
68
70

FIG. 2A


75
76
80
82
84
86
78
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AUDIO OUT
86
94
PN CODE REGISTER
88
90
CLOCK GEN. & LOGIC
RSSI

FIG. 2B

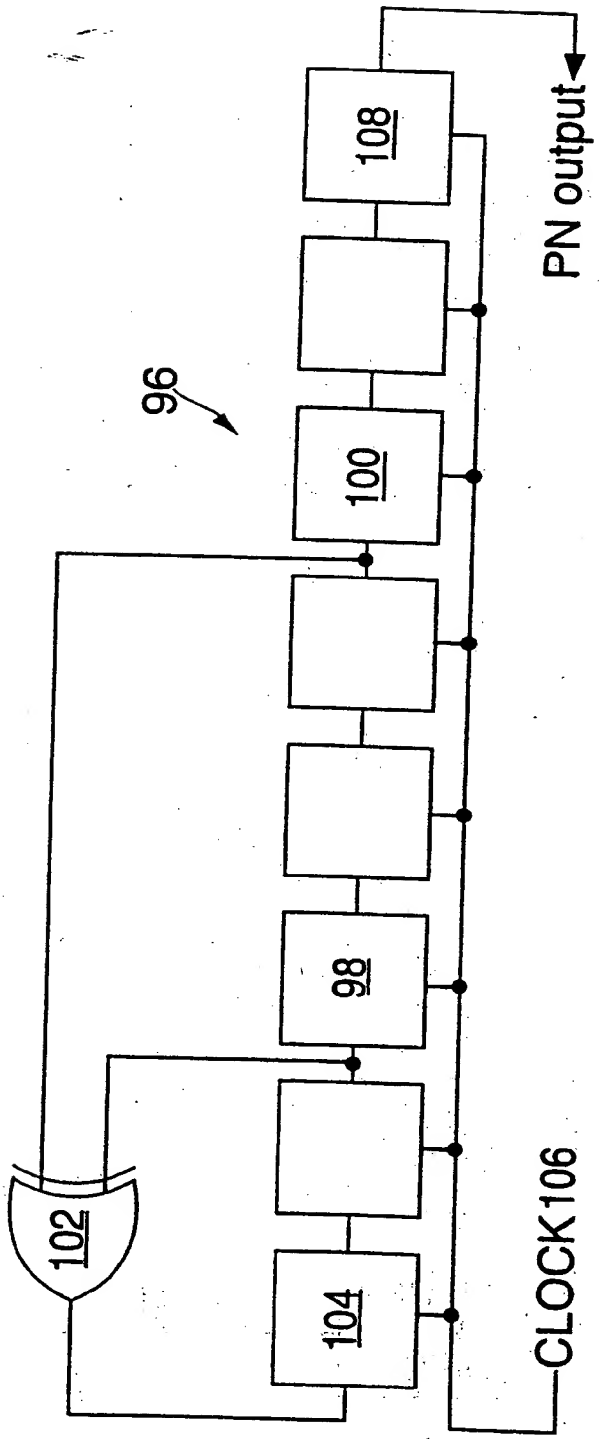

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/06127

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :H04H 5/00
US CL :381/14; 455/42

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 381/4,7,14,77,79,86; 455/42,110,115; 375/1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 3,590,382 (KENNEY) 29 June 1971.	1
A	US, A, 3,934,201 (MAJEFSKI) 20 January 1976.	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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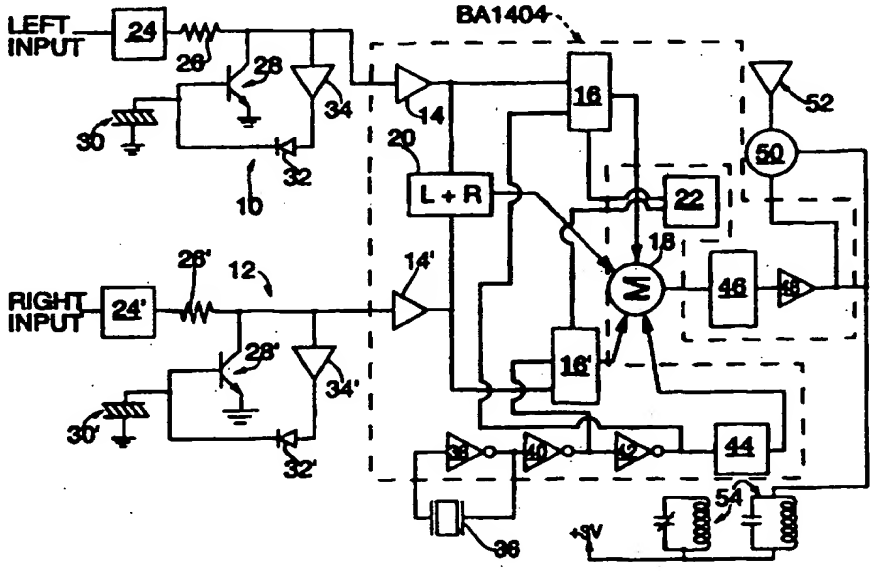

(57) Abstract

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GR	Greece
HU	Hungary
IE	Ireland
IT	Italy
JP	Japan
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KG	Kyrgystan
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KR	Republic of Korea
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LK	Sri Lanka
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
NE	Niger
NL	Netherlands
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